1st APSCO & ISSI-BJ Space Science School

Modeling Optimization and Realization of Spacecraft System Design Process based on DSM

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Outline

- Introduction of DSM
- GA based DSM Clustering Algorithm
- Example
- Summary

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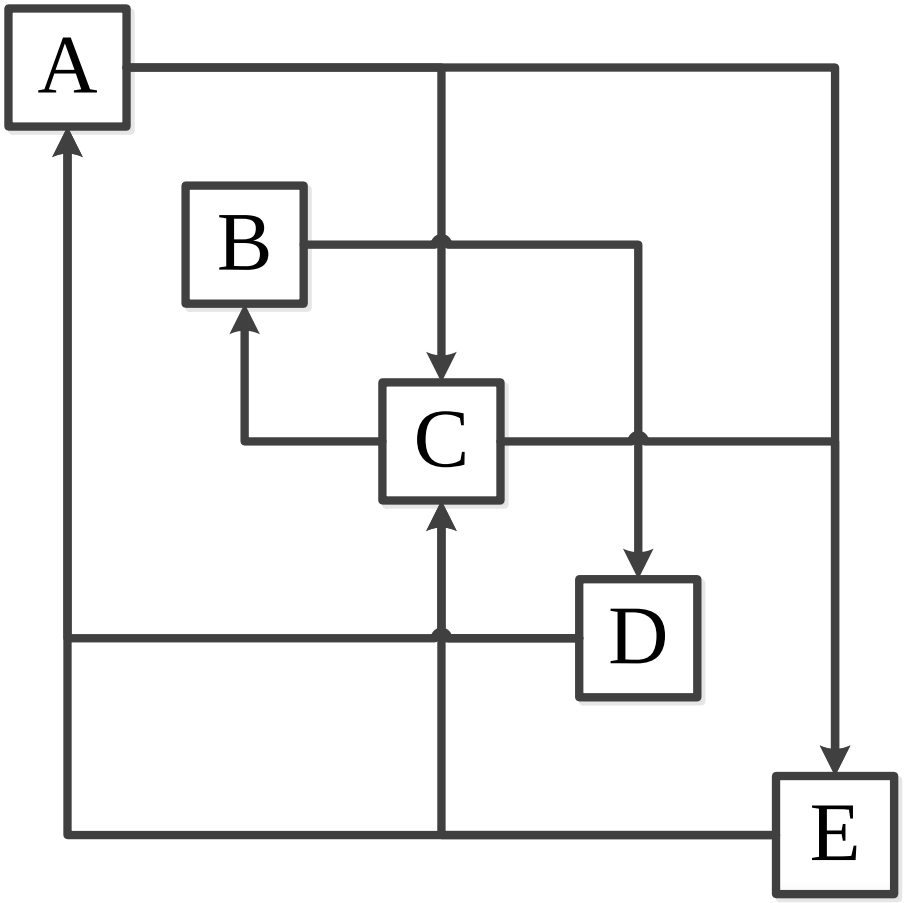
What is DSM

The design and development of complex spacecraft system design require the efforts and collaboration of hundreds of participants from diverse backgrounds resulting in complex relationships among both people and tasks. To intuitively describe the design process of spacecraft system , a matrix-based tool called the **Design Structure Matrix (DSM)** has evolved.

Design structure matrix (DSM) provides a simple, compact, and visual representation of spacecraft system. This method differs from traditional project-management tools because it focuses on representing information flows rather than work flows.

What is DSM



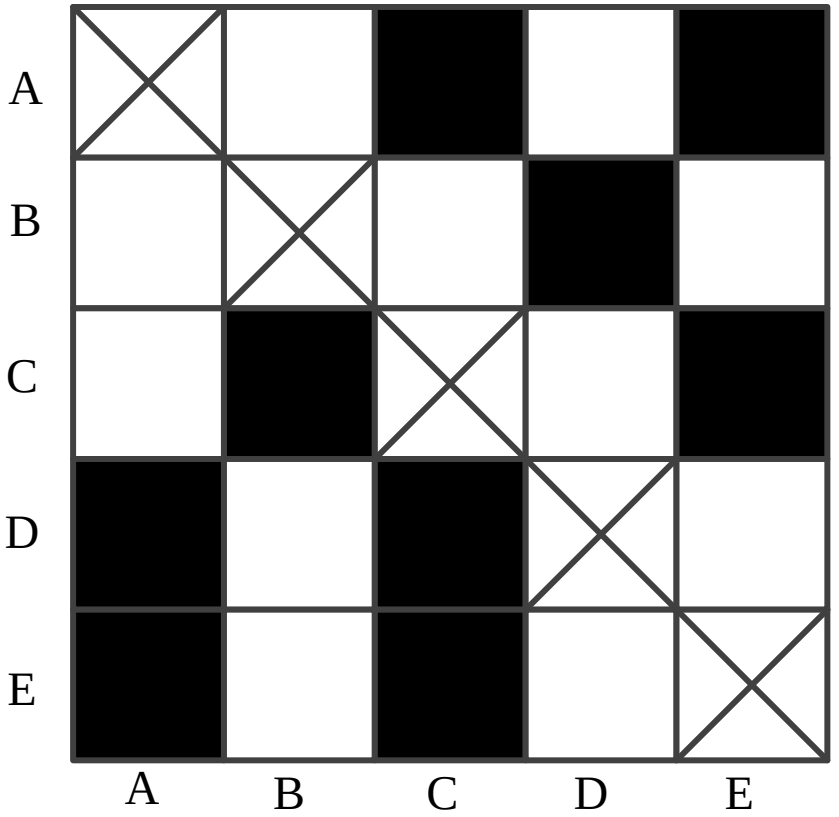


Illustration of a DSM

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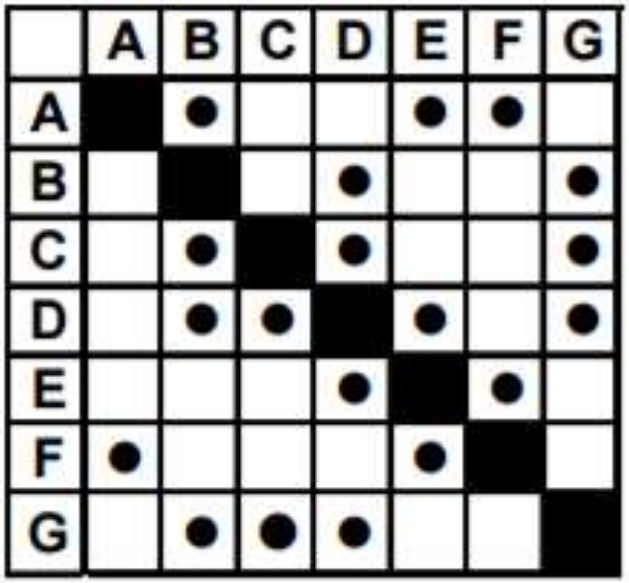
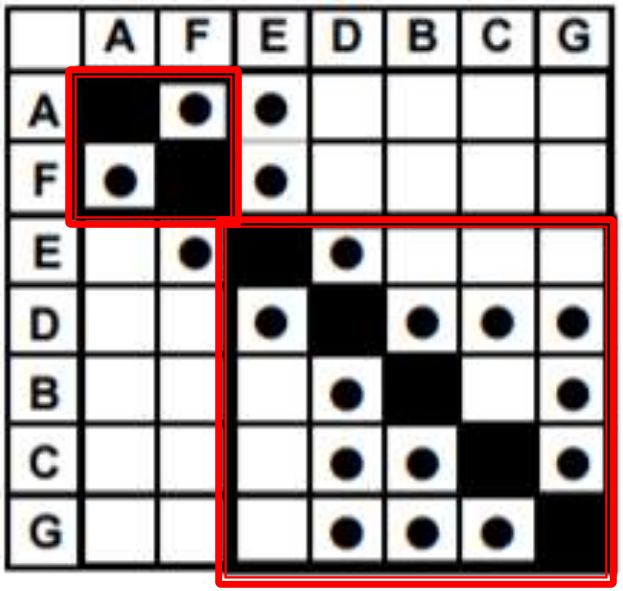
Clustering of DSM

The matrix can be manipulated in order to obtain clusters of highly interacting disciplines while attempting to minimize inter-cluster interactions. Each cluster can be considered as sub-system and be manipulated alone. In doing so, fewer disciplines will be involved in the iteration cycle resulting in a faster development process.



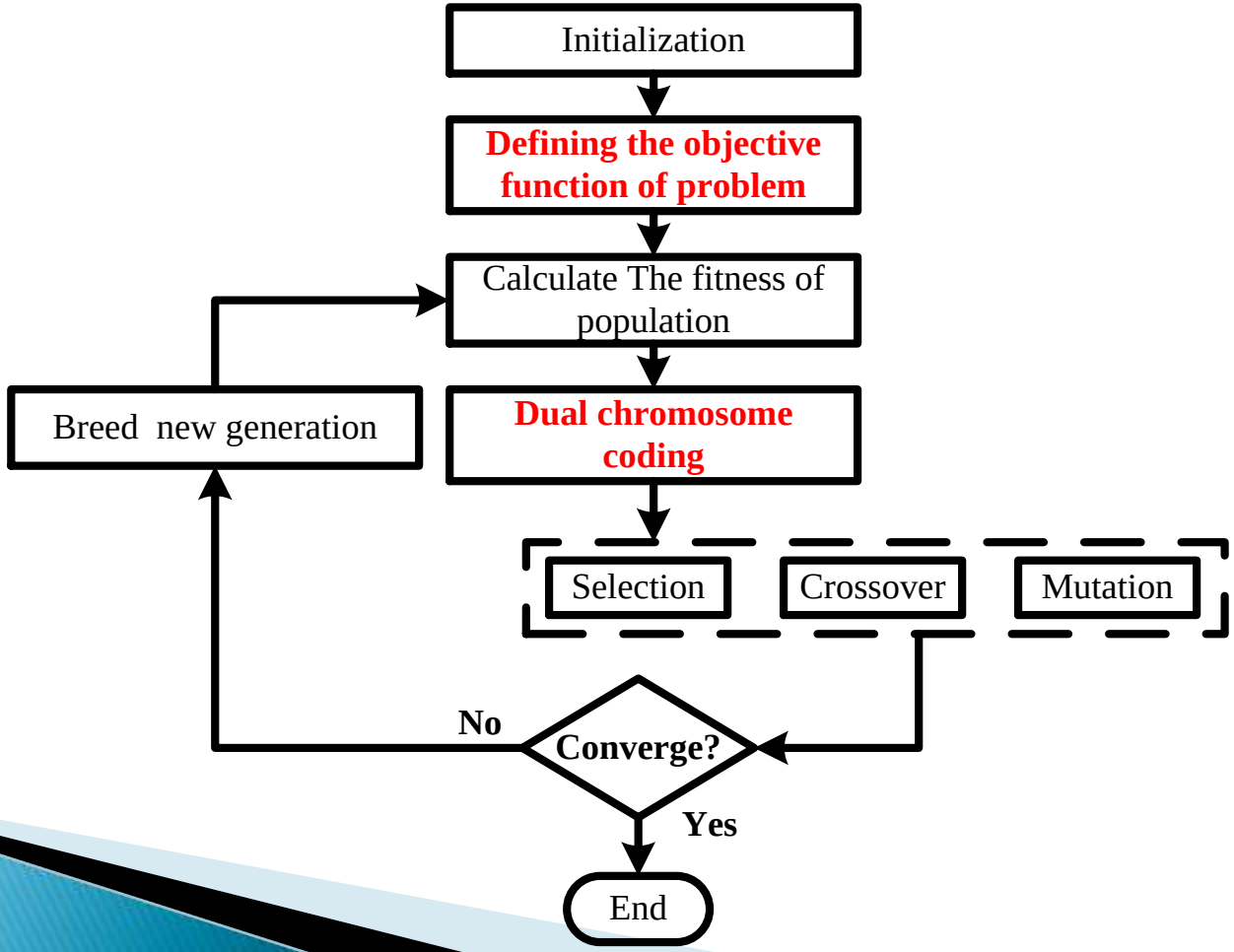
Initial DSM



DSM after clustering

GA based DSM Clustering Algorithm

We propose a DSM clustering method called **Genetic Algorithm based DSM Clustering Algorithm**. This method uses Dual Chromosome Coding method to determine the number of clusters automatically and the optimal clustering results.



Objective of the optimization problem

- **Contact information flow**

- Independent disciplines : have no interaction with another disciplines.
- "BUS" disciplines : have interaction with most of disciplines.
- Ordinary disciplines.

This method doesn't need much artificial operation, and it fit to each kind of DSM and large-scale DSM.

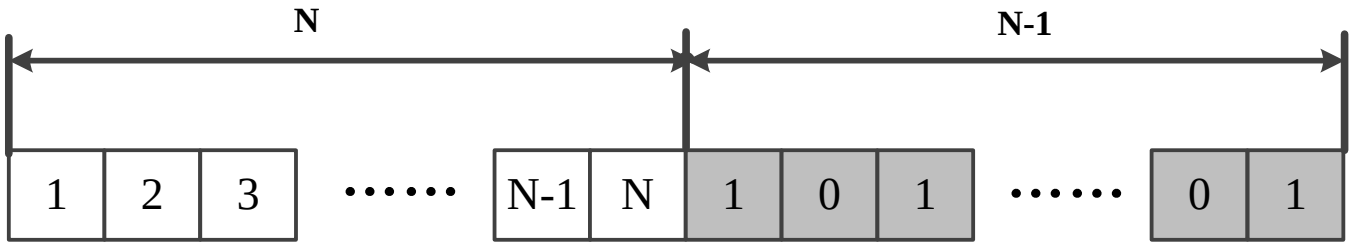
$$C_i = \sum_{j=1}^{n} \{D(i, j) + D(j, i)\} N_{i,j}^2$$

$$C = \sum_{i=1}^{n} C_i$$

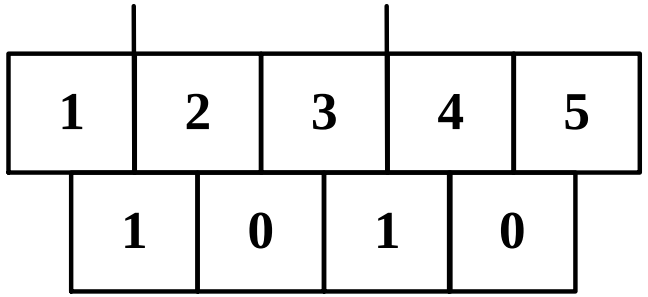
"n" is the number of clusters

➢Dual Chromosome Coding method

To reduce manual operation during the algorithm, we propose a genetic algorithm coding method called **Dual Chromosome Coding** which can obtain the number of cluster automatically as the algorithm iterating.



Dual Chromosome Coding method



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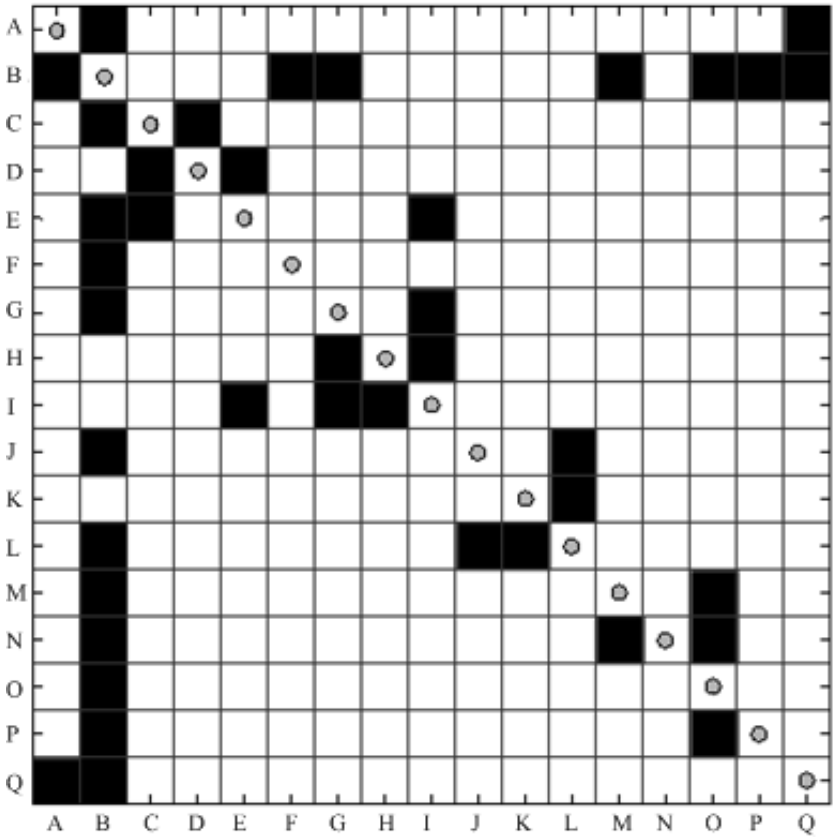
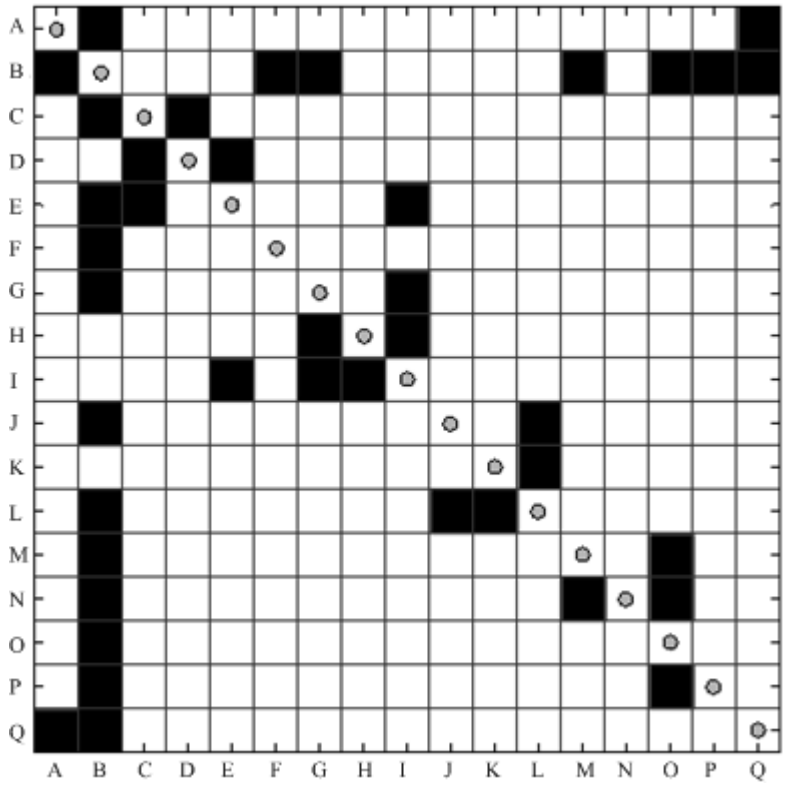
Example DSM

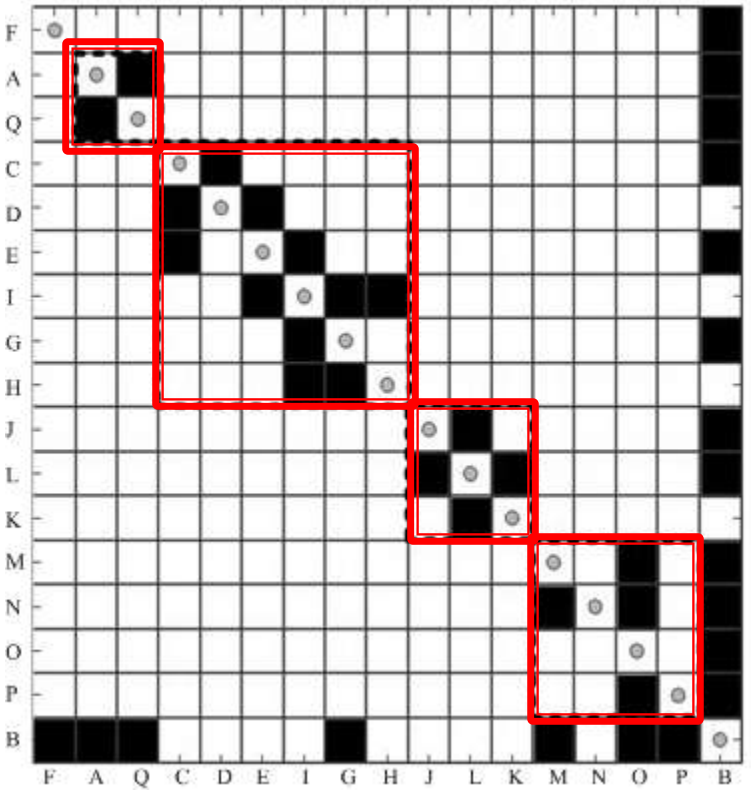


Initial DSM

The initial DSM was rearranged to contain most of the interactions within four separate clusters, one independent discipline and one BUS discipline. **Clusters contain most of the interactions internally and the interactions or links between separate clusters is eliminated**. So each cluster can iterate parallel, and the whole system design process become more efficient.



Initial DSM



DSM after clustering

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Summary

- The DSM provides visually powerful means for capturing, communicating, and organizing complex system design activities .
- We propose a new method based GA, which can manipulate the DSM with a high efficiency and less manual operation.
- An spacecraft system design example with 17 disciplines is presented to illustrate the effectiveness of the proposed GA based DSM Clustering Algorithm.

Thank you
for your attention!